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# Water Absorption Ratio and Flexural Strength Characteristics of Lightweight Composite Panel Surface Material Based on Addition Ratio of Powdery Modified Sulfur†

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In this study, we compared the water absorption ratio and flexural strength properties based on addition ratio of powdery modified sulfur to decrease the water absorption ratio of lightweight composite panel surface material. The water absorption ratio decreased as the addition ratio of powdery modified sulfur increased, while the density and flexural strength tended to increase.

**Keywords: Powdery modified sulfur, Magnesium, Lightweight composite panel.**

## INTRODUCTION

Great deals of efforts have been made to extend the life of the apartment houses/buildings in Korea. However, domestic apartments have fundamental problems that inhibit long lifespan of apartment houses/buildings and the primary cause is the bearing wall type structure. Although this bearing wall type structure complicates the alteration of internal space and remodeling, making it difficult to accommodate the diversity of living for residents, despite the advantage that it provides convenience of construction and shortens construction period. To improve such shortcomings, the structure has shifted from existing bearing wall type structure to Rahmen structure. The apartment houses/buildings built with Rahmen structure uses lightweight panels that are produced at factory to erect internal partition walls[1,2]. However, the lightweight panels which are produced at factor sometimes cause displacement of lightweight panel due to high water absorption ratio, or cause the surface material and core materials to be peeled off, or cause partial detachment[3].

Although conventional modified sulfur was found to effective in reducing the water absorption ratio of modified sulfur, there has been less study investigating the powdery modified sulfur. Thus, this study is intended to evaluate the water absorption ratio and flexural strength of lightweight composite panel surface material based on the addition rate of powdery modified sulfur in order to help resolve the problems of lightweight composite panel surface material, such as displacement, peeling and detachment.

## EXPERIMENTAL

This study aimed to determine the physical and mechanical properties of lightweight composite panel surface material based on addition ratio of powdery modified sulfur. The experiment was conducted by adding the powdery modified sulfur at the addition ratio of magnesium oxide 0, 5, 10, 15, 20 (wt. %). The magnesium chloride was added at a ratio of magnesium oxide 20 wt. % and the W/B was 50 %. The experiment level and design are presented in Table-1 and the mixing is presented in Table-2.

TABLE-1
EXPERIMENTAL FACTOR AND LEVEL

| Factor | Level | |
|---|---|---|
| W/B | 50 % | 1 |
| Powdery modified sulfur addition ratio | 0, 5, 10, 15, 20 (wt. %) | 5 |
| Wood flour addition ratio | 20 wt. % | 1 |
| Curing condition | Relative humidity (80 ± 5) %, Temperature (20 ± 2) °C | 1 |
| Test items | Water absorption ratio, Density, Flexural strength | 3 |

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TABLE-2
MIX DESIGN

| W/B (%) | Powdery modified sulfur addition ratio (%) | Light-burned magnesium (g) | Magnesium chloride (g) | Wood flour (g) | Powdery modified sulfur (g) | Water (g) |
|---|---|---|---|---|---|---|
| 50 | 0 | 3,000 | 600 | 600 | 0 | 1,500 |
| | 5 | | | | 150 | |
| | 10 | | | | 300 | |
| | 15 | | | | 450 | |
| | 20 | | | | 600 | |

The powdery modified sulfur used in this study was developed by "H" Company. The powdery modified sulfur is produced through pulverization of modified sulfur made by mixing 70-80 % sulfur, dicyclopentadiene, modifier, inorganic matter, *etc*. Existing modified sulfur has the disadvantage of inconvenience, requiring the solid to be molten into liquid state. By contrast, the powdery modified sulfur eliminated the need for melting.

The magnesium oxide used in the experiment applied sintered light-burned magnesium oxide at 600-1000 °C, has a density of 3.24 kg/m$^3$ and particle size below 200 mesh. The magnesium chloride is a German product, has a density of 1.59 kg/m$^3$ and flake shape. Its colour ranged from achromatic colour to white colour and used industrial products. The wood flour came from miscellaneous woods at woodworking shop and was below 2 mm. The chemical component of the materials used in this study is presented in Table-3.

## RESULTS AND DISCUSSION

**Water absorption ratio:** The test results of water absorption ratio showed that relatively all test specimens exhibited high water absorption ratio. That is considered attributable to very high water absorption ratio of wood flour itself and the wood flour matrix tissue being interconnected to increase the water absorption ratio. The water absorption ratio was the lowest in the test specimen added with 15 % powdery modified sulfur, followed by 20 % powdery modified sulfur, 10 % powdery modified sulfur, 5 % powdery modified sulfur and plain. The powdery modified sulfur was found to decrease the water absorption ratio. As the powdery modified sulfur is an organic matter, it has the properties that keep itself separated from water, preventing the water from being absorbed inside and reducing the water absorption ratio. For the test specimen added with 20 % powdery modified sulfur, the density decreased below 15 % addition rate of powdery modified sulfur as shown in Fig. 1, thus increasing the water absorption ratio.

**Density:** The test results showed that the plain was found to have a density of 0.95 kg/m$^3$, the lowest and that the density increased as the addition amount of powdery modified sulfur increased. The increase in density is considered attributable to the increased volume as a result of the increase in the powdery modified sulfur addition (Fig. 2). The 15 % addition rate of powdery modified sulfur, which led to the highest density, increased density by 0.14 kg/m$^3$ more compared to the plain. Density is the main factor that had the greatest impact on water absorption ratio and strength. However, the density was found to be 0.14 kg/m$^3$ in the test specimen of the highest PMS15 % and the lowest plain. Although this leads to a change in water absorption ratio and strength, the difference is not considered significantly.

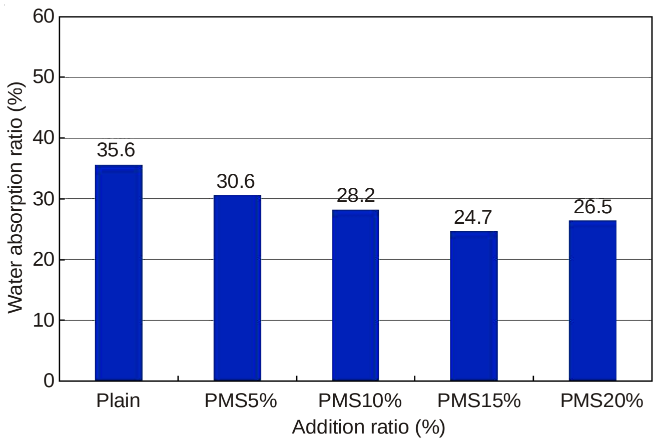

Fig. 1. Water absorption ratio

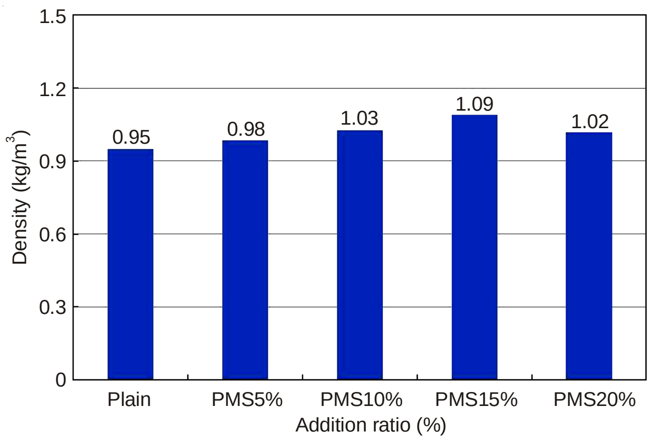

Fig. 2. Density

TABLE-3
CHEMICAL COMPONENT OF THE USING MATERIALS

| Using materials | Chemical component (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $MgO$ | $MgCl_2$ | $H_2O$ | $SO_3$ | $SiO_2$ | $Al_2O_3$ | $CaO$ |
| $MgO$ | 88.25 | – | – | – | 1.71 | 0.33 | 1.84 |
| $MgCl_2$ | – | 47.20 | 51.20 | – | – | – | – |
| PMS | – | – | – | 53.30 | 30.00 | 9.94 | 1.25 |

**Flexural strength:** The measurement results of flexural strength showed that the flexural strength was the highest in the test specimen with 15 % addition rate of powdery modified sulfur and that the strength of 3.6 MPa was manifested at the age of 28 days (Fig. 3). Meanwhile, the 3.5 MPa of flexural strength was manifested in test specimens with 20 % addition rate and 10 % test addition rate and 1.9 MPa of flexural strength was manifested in test specimen with 5 % addition rate. And 1.2 MPa of flexural strength was manifested in plain test specimen. The primary cause was the variation in strength due to the influence of density. As the density increased, flexural strength also increased.

The difference in flexural strength is considered to have been caused by very small difference in density because the material is the lightweight matrix. Furthermore, flexural strength which was as low as 1.2 MPa manifested itself in the plain due to high W/B.

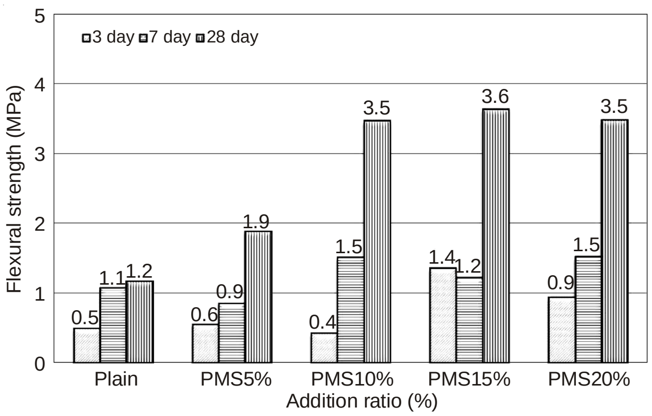


Fig. 3. Flexural strength

## Conclusions

The water absorption ratio and compressive strength in lightweight composite panel surface material based on the addition rate of powdery modified sulfur have the following characteristics:

• The measurement results of water absorption ratio showed that the water absorption ratio decreased as the addition ratio of powdery modified sulfur increased. The powdery modified sulfur was found effective in decreasing the water absorption ratio.

• The measurement results of density suggested that the density increased slightly as the addition ratio of powdery modified sulfur increased.

• The flexural strength increased as the addition ratio of powdery modified sulfur rises.

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